

CUSHION SUB

Instruction Manual 4105



Cushion Sub



Cushion Sub

INDEX

Cushion Sub	
General Description	3
Operation	3
Maintenance	3
Problem Solving	4
Complete Disassembly	4
Complete Assembly	5
Mandrel Body Assembly	5
Spline Body Assembly	5
Mandrel Assembly (11" to 12" Tool Only)	6
Assembly of Mandrel Body, Spline Body, and Mandrel as a Unit	6
Middle Body Assembly	6
Assembly of Bottom Sub Assembly	6
Assembling the Middle Body and and Bottom Sub Assemblies	7
Final Major Assembly	7
Filling the Tool with Oil	8
Testing	8
Illustrations	
Packing, Ring, and Seal Reassembly	9
Detailed Exploded View	10
Joint Torque Data and Test Load Chart	11
Bit Load Chart	12 – 15
Cushion Sub Service Kit	16
Specifications and Replacement Parts	17 – 19

The designs and specifications for the tools described in this instruction manual were in effect at the time this manual was approved for printing. National Oilwell Varco, whose policy is one of continuous improvement, reserves the right to discontinue models at any time, or to change designs and specifications without notice or without incurring obligation.

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General Description

The **Bowen Cushion Sub** provides for the highest drilling penetration rate by virtually eliminating the variable dynamic loading conditions on the bit.

The extremely long stroke, combined with a very low spring rate, provides a soft impact energy absorption system that greatly increases penetration and extends bit life.

As a bit rotates, it tends to generate a three-lobed cutting pattern on the bottom of the hole. Three times each revolution, the bit cones must ride up over the ridges thus formed and drop back into the pattern.

If the bit is directly connected, the large mass of the drill collars must be accelerated up and down in synchronism with the motions of the bit. This causes repetitive peak forces on the bit which may be several times the static bit weight, causing bit bounce. These cyclic forces also generate large stress waves in the drill string, which shorten the life of the drill pipe and bit can cause strong vibrations and damage to the rig equipment. These factors necessitate drilling at less than optimum bit weight and rpm.

Operation

The Bowen Cushion Sub should be located as close above the bit as possible, where it can function best to absorb these deflections with minimum variation in bit load, and minimum transmission of stress waves and vibrations up the drill string. Its function is similar to that of the spring and shock absorber on a wheel traveling over a rough road — it keeps the wheel on the ground while isolating the “bumps” from the vehicle. This is accomplished by means of a hydraulic spring.

As weight is lowered on the Cushion Sub, it will cause deflection of the hydraulic spring until the spring load balances the weight. Now, as the bit rotates and is deflected up over the ridges in the bottom hole pattern, it need not displace the massive drill collars above it; it need only deflect the spring slightly. As the bit drops back into the depressed portion of the bottom hole pattern, the hydraulic thrust follows it down, maintaining it on the bottom at all times and minimizing the variations in bit weight throughout the cycle.

The Cushion Sub adjusts automatically to any desired bit weight within its working range.

Maintenance

The Bowen Cushion Sub should be thoroughly washed and cleaned to remove all drilling mud and other debris. All parts should be examined for wear and damage and replaced as necessary. It is recommended that the Cushion Sub be completely disassembled, cleaned, either lubricated or painted and reassembled after each use before storing.

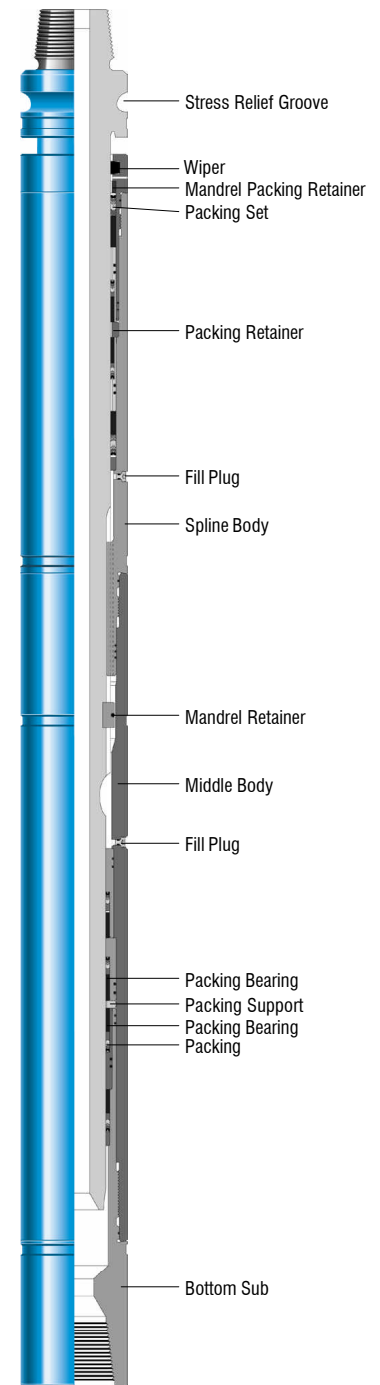


Figure 1
Cushion Sub

Problem Solving

1. To check the condition of the Cushion Sub after removal from the hole, stand the tool back and allow the weight of the collars above the tool to close the Cushion Sub slightly. Service the tool, if the gap is less than 1-1/2", or if the tool has been in use for the recommended number of hours.

NOTE: The Cushion Sub will function properly until it closes completely.

2. Excessive vibrations are sometimes encountered when drilling with the Cushion Sub. Often, the problem can be solved by changing the rpm, the weight-on-bit, the mud pump pressure, or some combination of these parameters.

Certain string length and rpm combinations can cause vibrations. There are two formulas given in the API Recommended Practice for Drill Stem Design and Operating Limits manual which are used to calculate the approximate rpms that may cause vibrations in the drill string. They are:

$$1) \text{ rpm} = 4,760,000 \times D^2 + d^2 \Rightarrow L^2$$

where:

rpm = critical speed

(revolutions per minute)

L = length of one pipe (inches)

D = outside diameter of pipe (inches)

d = inside diameter of pipe (inches)

$$2) \text{ rpm} = 258,000 \Rightarrow L$$

where:

rpm = critical speed

(revolutions per minute)

L = total length of string (feet)

Avoid the critical rpms if excessive string vibrations are being encountered.

Complete Disassembly

All item numbers will coincide with the exploded view drawing on page 8. Please refer to it for location of each part during disassembly and assembly procedures of the Cushion Sub.

USE CARE DURING DISASSEMBLY TO ASSURE NO GAS IS TRAPPED INTERNALLY.

REMOVING COMPONENTS UNDER PRESSURE IS VERY HAZARDOUS.

When disassembling tool avoid clamping directly on a Fill Plug Hole.

Place tool in a vise and break all connections. (On 11" – 12" O.D., see Disassembly Instructions for 11"–12" Cushion Sub.) The Mandrel Body to Spline Body connection has a left hand thread.

Clamp tool in a vise around Spline Body, place an oil catch tray or other containment device under the Middle Body (15) and Spline Body (1) joint. Unscrew this joint completely and pull the section apart several inches until the oil begins to drain. After draining is completed, pull the Middle Body section back until the Mandrel Retainer (14) is exposed. Remove the O-Ring (Item No. 29) on the retainer and tap the retainer lightly until it drops free. Push the Middle Body unit back in place and make up about four turns on the Spline Body threads. Attach thread subs on ends; place in jar tester and pull Mandrel (13) completely out of the assembly with the jar tester.

Place the tool back in the vise and disassemble as before, removing the Middle Body unit. Unscrew the Mandrel Body from Spline Body (left hand threads). Remove the bearing rings, packing, and retainers from Mandrel Body either by hand or with the aid of tool, Item No. 60.

To remove packing, retainers, and bearings from Spline Body, using tool (Item No. 59-A), enter from the spline end of the Spline Body; move tool into Spline Body until beyond splines. Straighten tool from horizontal position to vertical position (See Figure 2). Push unit until engaged in the packing retainer, Item No. 2-B. Holding firmly in place, and with the aid of a mallet, hit the end of the bar lightly. It may be necessary to rotate slightly when striking the end of the bar. With the aid of disassembly tool, Item No. 59-A, the parts can be easily removed from the assembly.

Place the Middle Body and Bottom Sub Unit (23) in the vise and unscrew this joint completely.

Using disassemble tool, Item No. 57, against shoulder of Packing Retainer, Item No. 24, inside bottom sub, tap lightly with mallet while rotating tool slightly each time. Repeat this process to remove all parts from Bottom Sub. To remove optional Bottom Sub (Pin Type) Assembly, use Disassembly Tool shown in Figure 2 (Item No. 72).

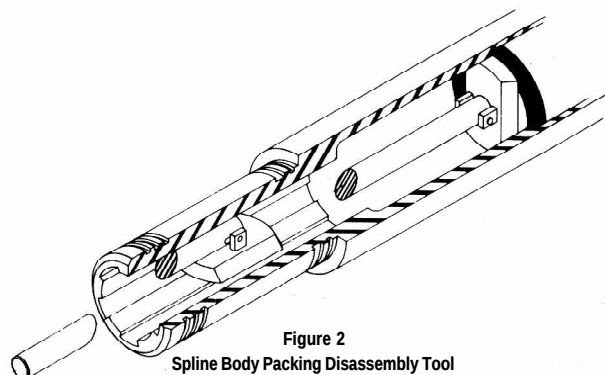


Figure 2
Spline Body Packing Disassembly Tool

Using Disassembly Tool, Item No. 58, and an extension to clear the end of the Middle Body by about 24", insert tool into the Middle Body until it rests against shoulder of Packing Retainer, Item No. 16. Tap lightly with mallet while rotating tool slightly each time to remove all parts from Middle Body.

It is recommended that all parts be cleaned thoroughly and all O.D. bodies magnetic particle inspected prior to reassembly.

Disassembly Instructions for 11"-12" Cushion Sub

Place tool in a suitable vise, clamping on the Middle Body. Break the Bottom Sub and unscrew several turns.

Reposition and clamp on the Spline Body. Place an oil catch tray or other containment device under the Middle Body and Spline Body. Break the Middle Body and unscrew and pull apart several inches. This is to allow the oil to drain and to release any pressure that may have become trapped in the tool. Push this connection back together and screw together several turns.

Reposition the clamp on the Middle Body and unscrew and remove the Bottom Sub. Reposition the clamp on the Spline Body and unscrew and remove the Middle Body. Break and remove the Mandrel Extension.

NOTE: This joint is torqued to 20,000 ft/lbs.

Turn the tool around in the vice and clamp on the Spline Body. Break and loosen the Top Sub. Push the Mandrel slightly closed and remove the Mandrel Retainers. Pull the Mandrel out until loose but still engaged in the splines and unscrew and remove the Top Sub. Remove Mandrel.

Break and unscrew the Mandrel Body from the Spline Body.

NOTE: This connection has left-hand threads.

Remove all O-Rings, Packing, Packing Supports, Packing Retainers, Wipers, and Bearings. Steam clean and inspect all parts for damage. Follow inspection guidelines outlined in Inspection Procedures for Cushion Subs.

Complete Assembly

All item numbers will coincide with the exploded view drawing on page 9. Please refer to it for location of each part during disassembly and assembly procedures of the Cushion Sub.

All metal parts should be thoroughly cleaned, or washed inside out with a good grade solvent; blown dry with shop air, or wiped clean with soft cloths. The parts should then be thoroughly oiled with a good grade clean light oil.

NOTE: Always lubricate threads with an approved thread lubricant (KOPR-KOTE.)

When assembling tool avoid clamping directly on a Fill Plug Hole.

1. Mandrel Body Assembly

Assemble these parts as follows, within the Mandrel Body, Item No. 10, beginning with the Wiper, Item No. 11. Then install (1) Packing Retainer, Item No. 2-A, followed by (1) Packing Set, Item No. 4.

Refer to Packing, Ring and Seal Reassembly Guide (page 8) for packing set sealing direction. Install (2) Bearings, Item No. 12, (1 only required on 9"-9-1/2" and 4-3/4" - 5-1/4" O.D. Tool). Place (2) O-Rings, Item No. 28, on (1) Packing Support, Item No. 5; note location and direction of each from Packing, Ring and Reassembly Guide (page 8). Install this support assembly in Mandrel Body bore firmly against the previously installed bearing rings.

NOTE: No Packing support required on 4-3/4" - 5-1/4" O.D. Tool.

Next, install (1) Bearing, Item No. 6, (This Bearing only, not required on 9" - 9-1/2" O.D. Tool) into already installed packing support, followed by (1) Packing Set, Item No. 7. Refer to Packing, Ring and Seal Reassembly Guide (page 8) for Packing Set sealing direction. Finally, install (1) Bearing, Item No. 6, against the Packing Set.

Install (2) O-Rings, Item No. 32, noting location in the Mandrel Body external grooves. Install O-Ring, Item No. 33, in groove near shoulder.

This completes the assembly of the Mandrel Body. Set this unit aside until the Spline Body is ready for assembly with the Mandrel Body.

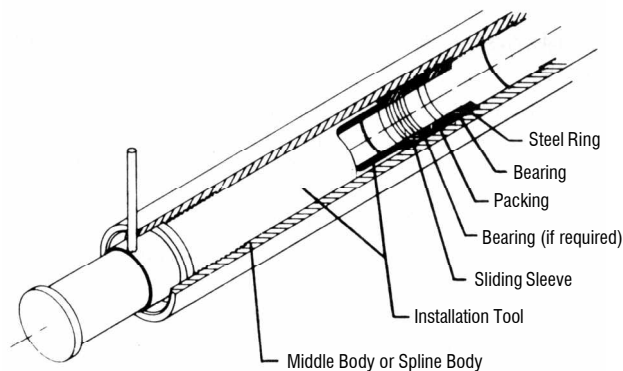


Figure 3
Middle Body Packing or Spline Body Packing Installation Tool
(4-3/4" to 5-1/4" OD Tool Only)

2. Spline Body Assembly

Install (1) Packing Retainer, Item No. 2-B, into Spline Body, Item No. 1. Using the same procedure, install (1) Bearing, Item No. 3, (This Bearing only, not required on 9" – 9-1/2" and 4-3/4" – 5-1/4" O.D. Tool), followed by (1) Packing Set, Item No. 4. Refer to Packing, Ring and Seal Reassembly Guide (page 8) for Packing Set sealing direction. Install (1) Bearing, Item No. 3, against packing. Use the Spline Body Packing Installation Tool (Item No. 59-B) to install the previously mentioned parts in the 4-3/4" – 5-1/4" O.D. Tool (See Figure 3 below).

Place (2) O-Rings, Item No. 28, on (1) Packing Support, Item No. 5; note location and direction of each from Packing, Ring and Seal Reassembly Guide (page 8). Install (1) Bearing, Item No. 6, (This Bearing only, not required on 9" – 9-1/2" and 4-3/4" – 5-1/4" O.D. Tool) into Packing Support, followed by (1) Packing Set, Item No. 7. Refer to Packing, Ring and Seal Reassembly Guide (page 8) for Packing Set sealing direction. Install (1) Bearing, Item No. 6 against the Packing Set. Install Support Assembly in Spline Body Bore followed by the Packing Retainer, Item No. 8. Pushing against the Packing Retainer with the Mandrel Body Packing Disassembly Tool, Item No. 60, or the Spline Body Packing Disassembly Tool, Item No. 59-A, install Support Assembly and Packing Retainer until shouldered against the previously installed bearings in the Spline Body Bore. For the 4-3/4" – 5-1/4" O.D. Tool only, make up an identical support assembly. Install support assembly, bearing end first, into the Spline Body until it shoulders against the packing retainer.

On the spline end of this assembly, install (3) External O-Rings, Item No. 30. Install O-Ring, Item No. 31, in groove near shoulder. Assembly of Spline Body

and Mandrel Body is now complete. (IF 11" – 12" TOOL IS BEING ASSEMBLED, PROCEED TO STEP 3. ALL OTHER SIZES GO DIRECTLY TO STEP 4.)

3. Assembly Procedure for Mandrel Body, Spline Body, Mandrel, and Mandrel Extension of 11" – 12" O.D. Tool Only

Pick up the Spline Body and clamp in a vise. Install Mandrel Body and make up hand tight. (This joint has left-hand threads.) Pick up Mandrel and insert into the Mandrel Body/Spline Body Sub Assembly. Mandrel may need to be rotated slightly to engage the splines. Push Mandrel thru until the mandrel Retainers can be installed. Install the two retainer halves and O-ring to hold in place.

Pick up the Top Sub and install on the large end of the mandrel hand tight.

Pick up and install the Mandrel Extension and tighten to torque specifications in manual. Remove the Sub Assembly from the vise for now.

4. Assembly of Mandrel Body, Spline Body, and Mandrel as a Unit

Clamp the Spline Body assembly in vise.

A light coat of cup grease should now be applied to the inside area of the packing sets and bearings on both assemblies. After applying some KOPR-KOTE on threads and shoulders, carefully insert the mandrel body in to the Spline Body and rotate counterclockwise — these are left hand threads. Make up threads almost completely until an 1/8- to 1/4-inch gap remains between the shoulders. Do not tighten. Apply a heavy coat of grease to the seal area of the Mandrel, Item No. 13, and recess behind the Mandrel Body Wiper, Item No. 11. Before insertion on mandrel, apply Moly grease

containing Molybdenum disulfide in very fine particulate or chemical form (high bearing load lubricant) to splines. Do not use KOPR-KOTE or any metallic particulate type anti-gallant. Push spline end of Mandrel, Item No. 13, through wiper end of Mandrel Body, Item No. 10, until splines engage. Push Mandrel, Item No. 13 completely through both assemblies until the Mandrel Retainer groove for the Mandrel Retainer, Item No. 14 is completely exposed at the end of Spline Body. The jar tester may be used to push the mandrel through Mandrel Body and Spline Body assemblies. The Mandrel Retainer, Item No. 14, is to be installed in two pieces. When in place, this Retainer prevents the Mandrel from being removed.

Install the two Retainer halves as shown on the Packing, Ring and Seal Reassembly Guide (page 8). Install O-Ring, Item No. 29, in the groove on the rings. This is not a seal and is used only to hold these parts in place.

This part of tool is now complete and should be held in reserve until the lower half of the tool is assembled.

5. Middle Body Assembly

Assemble these parts as follows, within the Assembly Tool, Item No. 56 (See Figure 3). Pull the sliding sleeve of the Assembly Tool all the way out and grease the bore at the other end with cup grease. Install (1) Bearing, Item No. 17 into the bore. Next, install Packing Set, Item No. 18 against the bearing making sure that the packing inside the assembly tool is pointing in the same direction as on the Packing, Ring and Seal Reassembly Guide (page 8). Install (1) Bearing, Item No. 17. (This Bearing ONLY, not required on 9" – 9-1/2" and 4-3/4" – 5-1/4" O.D. Tool). The last part to install in the Assembly Tool is the Packing Retainer, Item No. 16. Grease lower

end of the Middle Body, Item No. 15, with cup grease. Insert Assembly Tool into the bore of the Middle Body until it makes contact with the shoulder. Push the sliding sleeve of the Assembly Tool in (a hammer may be used if necessary) until the Packing Retainer, Item No. 16, touches the shoulder next to fill plug hole. At this point, all parts are in place inside the Middle Body and the Assembly Tool (Shown in Figure 3) can be removed and set aside.

Place (2) O-Rings, Item No. 27, on Packing Support, Item No. 19; note location and direction of each, from Packing, Ring and Seal Reassembly Guide (Page 6). Install (1) Bearing Item No. 20, (This Bearing only, not required on 9" – 9-1/2" and 4-3/4" – 5-1/4" O.D. Tool) and (1) Packing Set, Item No. 21, check assembly for sealing direction, followed by (1) Bearing, Item No. 20, into the packing support. Install complete unit into bore in proper direction followed by the Middle Body Packing Retainer. Item No. 22. Pushing against the Packing Retainer with the Middle Body Packing installation tool, Item No. 56 or the Middle Body Packing Disassembly Tool, Item No. 58, install Support Assembly and Packing Retainer until shouldered against previously installed Bearings in the Middle Body.

This completes the installation of packing and associated items in the Middle Body.

6. Assembly of Bottom Sub Assembly

Apply a light coat of cup grease to bore of Bottom Sub, Item No. 23. Install Packing Retainer, Item No. 24, followed by (1) Bearing, Item No. 20. (This Bearing ONLY not required on 9" – 9-1/2" and 4-3/4" – 5-1/4" O.D. Tool.) Next, install (1) Packing Set, Item No. 21, — noting direction of sealing rings on assembly, and (1) Bearing, Item No. 20. Place (2) O-Rings, Item No. 26, on Packing Support, Item No. 25; note location and direction of each from Packing, Ring and Seal Reassembly Guide (page 8). Install this support assembly in bottom sub bore firmly against the previously installed Bearing Rings. Next, install (1) Bearing, Item No. 20. (This Bearing ONLY, not required on 9", 9-1/2", and 4-3/4" – 5-1/4" O.D. Tool) followed by (1) Packing Set, Item No. 21, — noting direction of sealing rings on Assembly, and (1) Bearing, Item No. 20. Install (2) O-Rings, Item No. 30, noting location in Bottom Sub external grooves. Install O-Ring, Item No. 31, in groove near shoulder.

All packing and bearing should receive a light coat of grease on I.D.

7. Assembling the Middle Body and Bottom Sub Assemblies (Lower Assembly)

Clamp the middle body in the vise and apply KOPR-KOTE to threads, shoulder, and small O.D. of Bottom Sub. Make up these bodies until the shoulder standoff is about 1/8 inch. Do not tighten.

8. Final Major Assembly

Clamp the Spline Body, Mandrel Body, and Mandrel Unit in a vise. Apply a light

coat of cup grease to the lower seal area of Mandrel. (On 11" and 12" O.D., tool is the Mandrel Extension.) A hoist must be used to lift the lower assembly into place.

Slide the lower assembly over the external mandrel end. Rotate slowly to prevent any damage to the packing in the bore.

Engage threads and make up to shoulder. Make up all joints to shoulders (including Top Sub in 11" – 12" O.D. tool only). Tighten for field use. Torque data shown on chart, page 11.

9. Filling the Tool with Oil

NOTE: (A Cushion Sub Service Kit, Part No. 81368, is required to fill tool with oil.)

The tool must be filled with Bowen Hydraulic Oil (Part No. 49842). This oil is recommended, but any ISO Grade 22 hydraulic oil having the required properties can be used, such as Sunvis 722 or Rando HD22. Open tool until Mandrel is fully extended. Tilt the tool approximately 45° with the Bowen Sub end down. (See Figure 4 below.)

Attach the input pump line to the lower fill plug hole and the return line to the upper plug hole. Pump the tool until full and continue circulation until air bubbles disappear. Install (2) Fill Plugs, Item No. 9, each fitted with (1) O-Ring, Item No. 34, and (1) Back-Up Ring, Item No. 35. Tool is now ready for testing.

10. Testing

Measure distance between Mandrel shoulder and Mandrel Body shoulder in the fully open tool. Compress the tool in the jar tester to load shown on Test Load Chart, page 10.

Release the load and allow the Mandrel to extend freely as far as it will go. Repeat this step 4 to 5 times. Check for leakage at Fill Plugs. After the last test, the Mandrel should be extended by internal pressure to within 2" + 1/2" of fully extended position. Add to or remove enough oil to allow the tool to extend to this range, if necessary. Then check Fill Plugs for leakage.

Test is complete. Paint the tool and attach Bowen "Cushion Sub" stickers.

Cushion Sub Service Kit

A Cushion Sub Service Kit is necessary to properly service the Tool. These Kits are identical for every size Cushion Sub. Pack-ing Installation or Packing Disassembly Tools must be ordered separately.

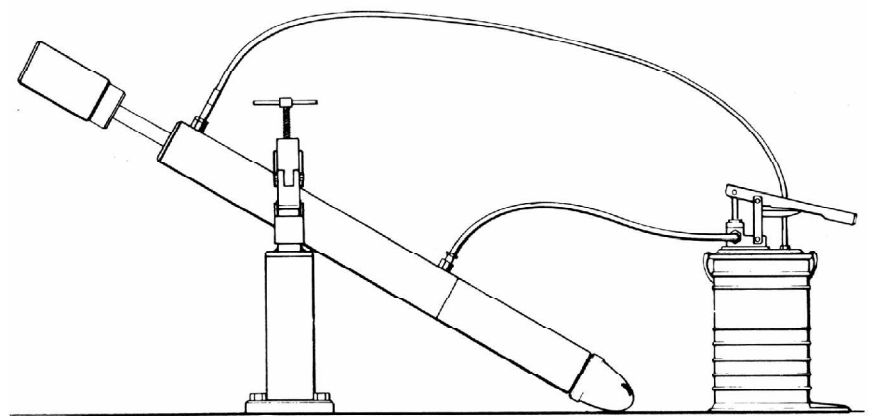
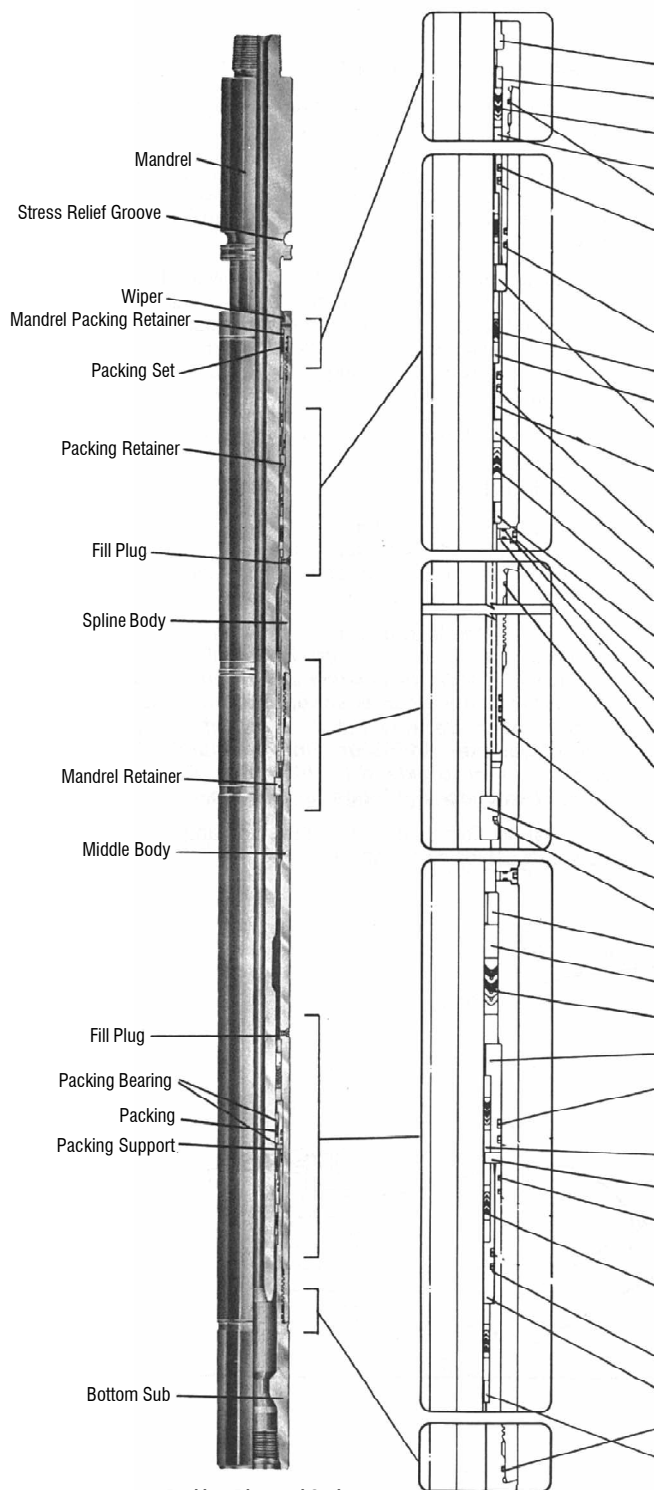
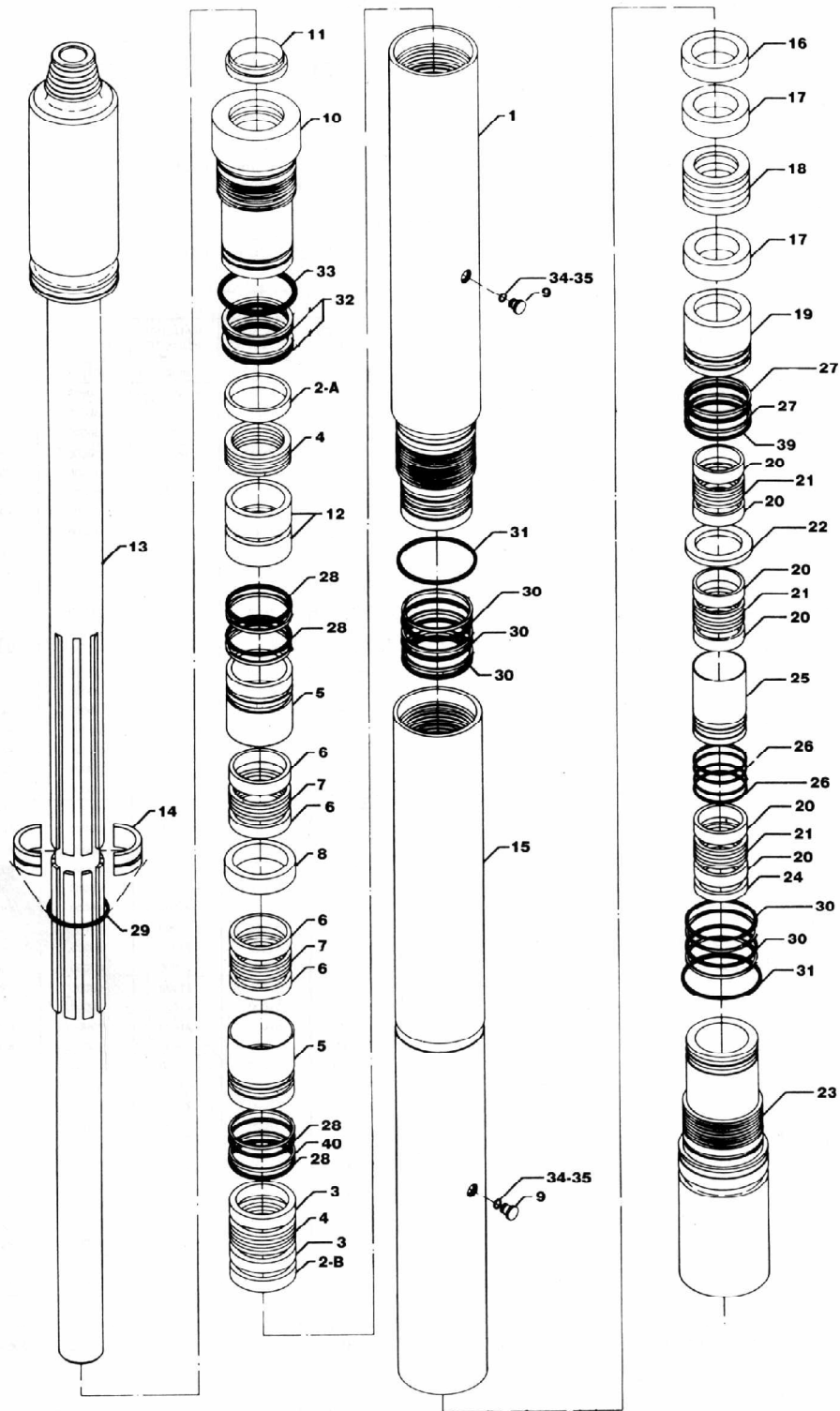


Figure 4
Filling the Cushion Sub



**Packing, Ring, and Seal
Reassembly Guide**

ITEM NO.	DESCRIPTION
11	Mandrel Body Wiper
2-A	Mandrel/Spline Body Packing Retainer
4	Mandrel Body and Spline Body Packing Set
12	Mandrel Body Bearing (2)
33	O-Ring (Large)
28	O-Ring (2)
32	O-Ring (Small) (2)
7	Mandrel & Spline Body Support Packing (1 of 2)
6	Mandrel & Spline Body Pkg. Support Bearing (1 of 4)
8	Spline Body Packing Retainer
5	Mandrel & Spline Body Packing Support (1 of 2)
28	O-Ring (2)
3	Spline Body Packing Bearing (2)
4	Mandrel Body and Spline Body Packing Set
2-B	Mandrel/Spline Body Packing Retainer
9	Fill Plug (1 of 2)
34	O-Ring (1 of 2)
35	Back Up Ring (1 of 2)
31	O-Ring (Large)
30	O-Ring (Small) (3)
14	Mandrel Retainer
29	O-Ring (No Seal)
16	Middle Body Packing Retainer (Long)
17	Middle Body Packing Bearing (2)
18	Middle Body Packing Set
19	Middle Body Packing Support
27	O-Ring (2)
20	Packing Bearing (1 of 6)
22	Middle Body Packing Retainer (Short)
30	O-Ring (Small) (2)
21	Packing Set (1 of 3)
26	O-Ring (2)
25	Bottom-Sub Packing Support
31	O-Ring (Large)
24	Bottom Sub Packing Retainer



Detailed Exploded View

Test Load Chart

Cushion Sub Size - O.D.	Test Load	Cushion Sub Size - O.D.	Test Load
4-3/4" - 5-1/4"	60,000 Lbs.	8" - 8-1/2"	110,000 Lbs.
6" - 6-1/4"	76,000 Lbs.	9" - 10"	120,000 Lbs.
6-1/2" - 7"	78,000 Lbs.	11" - 12"	120,000 Lbs.

Do not exceed the load rating in the jar tester. Overload may damage the tool.
Do not attempt to close the tool completely when testing.

Cushion Subs

Maximum Recommended Tightening Torque (Ft-lb) For Body Joints

Tool Sizes (Inches)		Body Joints			Tool Sizes (Inches)		Body Joints				
Nominal	Measured	Mandrel	Spline	Middle	Nominal	Measured	Top Sub	Mandrel	Mandrel	Spline	Middle
Size	Tool	Body To	Body To	Body To	Size	Tool	To	To	Body To	Body To	Body To
	O.D.	Spline	Middle	Bottom		O.D.	Mandrel	Mandrel	Spline	Middle	Bottom
		Body	Body	Sub			Extension	Body	Body	Body	Sub
4-3/4 TO	4-5/8	2200	3900	4500	9	8-3/4	—	—	12000	30000	30000
	4-11/16	2200	3900	5000		8-13/16	—	—	14000	30000	31000
	4-3/4	2200	3900	5900		8-7/8	—	—	16000	30000	33000
	4-13/16	2200	3900	5900		8-15/16	—	—	18000	30000	35000
	4-7/8	2200	3900	5900		9	—	—	18500	30000	36000
5-1/4 TO	5-13/16	3700	9600	9600		9-1/16	—	—	18500	30000	38000
	5-7/8	4500	9600	9700		9-1/8	—	—	18500	30000	40000
	5-15/16	4500	9600	10000		9-3/16	—	—	18500	30000	42000
	6	4500	9600	11000		9-1/4	—	—	18500	30000	42000
	6-1/16	4500	9600	12000		9-5/16	—	—	18500	30000	42000
6 TO	6-1/8	4500	9600	13000		9-3/8	—	—	18500	30000	42000
	6-3/16	4500	9600	13000		9-7/16	—	—	18500	30000	42000
	6-1/4	4500	9600	13000		9-1/2	—	—	18500	30000	42000
	6-1/4	4500	9600	13000		9-9/16	—	—	18500	30000	42000
	6-1/4	4500	9600	13000		9-5/8	—	—	18500	30000	42000
6-1/2 TO	6-1/4	4400	9600	11000	10	9-11/16	—	—	18500	30000	42000
	6-5/16	5400	9600	11500		9-3/4	—	—	18500	30000	42000
	6-3/8	5800	9600	12000		9-13/16	—	—	18500	30000	42000
	6-7/16	5800	9600	13000		9-7/8	—	—	18500	30000	42000
	6-1/2	5800	9600	14000		9-15/16	—	—	18500	30000	42000
7 TO	6-9/16	5800	9600	15000		10	—	—	18500	30000	42000
	6-5/8	5800	9600	15000		10-1/2	57000	20000	21000	56000	56000
	6-11/16	5800	9600	15000		10-9/16	57000	20000	21000	58000	58000
	6-3/4	5800	9600	15000		10-5/8	57000	20000	21000	60000	61000
	6-13/16	5800	9600	15000		10-11/16	57000	20000	21000	60000	63000
8 TO	6-7/8	5800	9600	15000		10-3/4	57000	20000	21000	60000	66000
	6-15/16	5800	9600	15000		10-13/16	57000	20000	21000	60000	68000
	7	5800	9600	15000		10-7/8	57000	20000	21000	60000	71000
	7-9/16	8600	16000	16500		10-15/16	57000	20000	21000	60000	74000
	7-5/8	8600	16000	18000		11	57000	20000	21000	60000	76000
8-1/2 TO	7-11/16	8600	16000	20000	11	11-1/16	57000	20000	21000	60000	79000
	7-3/4	8600	16000	21000		11-1/8	57000	20000	21000	60000	82000
	7-13/16	8600	16000	22000		11-3/16	57000	20000	21000	60000	84000
	7-7/8	8600	16000	23000		11-1/4	57000	20000	21000	60000	87000
	7-15/16	8600	16000	23000		11-5/16	57000	20000	21000	60000	90000
8-1/2 TO	8	8600	16000	23000		11-3/8	57000	20000	21000	60000	92000
	8-1/16	8600	16000	23000		11-7/16	57000	20000	21000	60000	95000
	8-1/8	8600	16000	23000		12	57000	20000	21000	60000	95000
	8-3/16	8600	16000	23000		11-1/2	57000	20000	21000	60000	95000
	8-1/4	8600	16000	23000		11-9/16	57000	20000	21000	60000	95000
8-1/2 TO	8-5/16	8600	16000	23000		11-5/8	57000	20000	21000	60000	95000
	8-3/8	8600	16000	23000		11-11/16	57000	20000	21000	60000	95000
	8-7/16	8600	16000	23000		11-3/4	57000	20000	21000	60000	95000
	8-1/2	8600	16000	23000		11-13/16	57000	20000	21000	60000	95000
	8-1/2	8600	16000	23000		11-7/8	57000	20000	21000	60000	95000
	8-1/2	8600	16000	23000		11-15/16	57000	20000	21000	60000	95000
	8-1/2	8600	16000	23000		12	57000	20000	21000	60000	95000

The above make up torques are the maximum recommended make up torques for each connection. They are set at 50% of the calculated theoretical yield torque.

The chart lists the recommended safe tightening torque for each body joint. Always use the torque value listed beside the measured tool O.D.

The tightening torque values were calculated assuming Itcolube or similar zinc based grease on all threads and shoulders.

Cushion Sub Hydraulic Charts

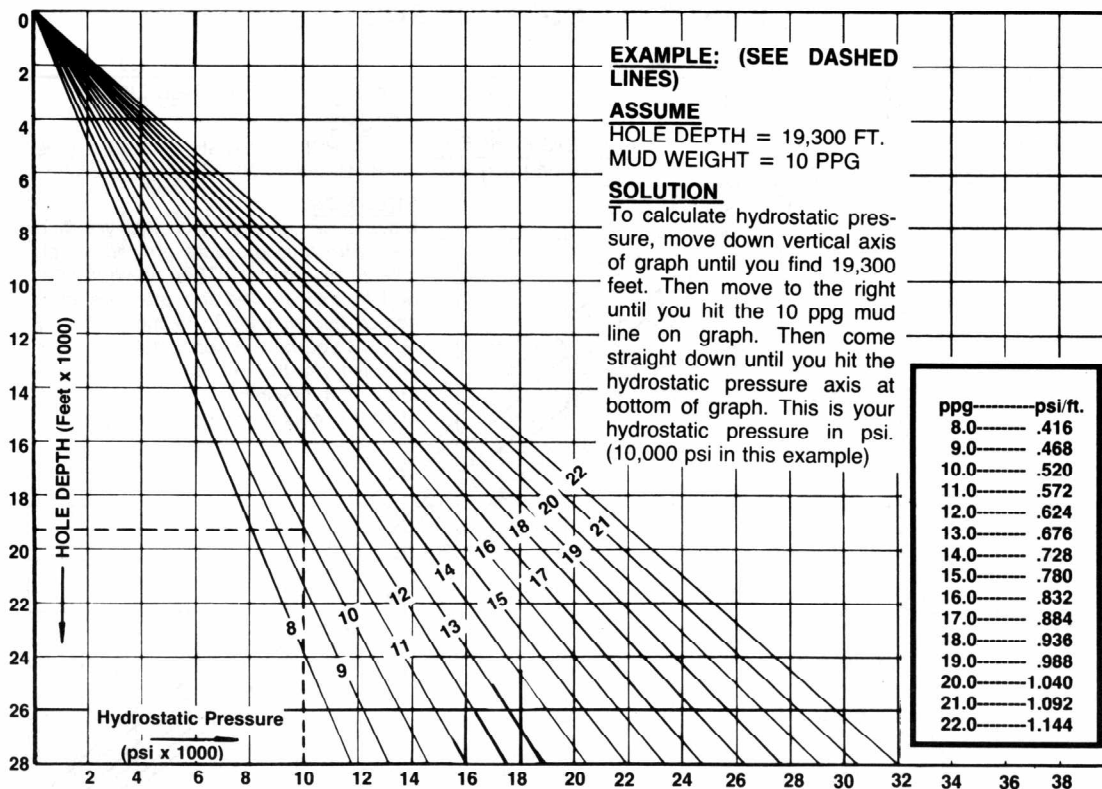
The following graphs (1) through (7) can be used to calculate the pump open or pump closed force on any size Cushion Sub. There are examples on each graph which show how to use them. If the graphs show that the Cushion Sub has a CLOSING force, then NO minimum bit weight is required to operate the Sub. But if the graphs show that there is an OPENING force on the Cushion Sub, the weight on bit applied by the driller must be greater than the opening force. Otherwise, the tool will be fully pumped open and will not operate properly. If the driller is unable or unwilling to put enough weight on the bit, the pumps could be cut back a little to lower the opening force on the Cushion Sub. This could allow the Sub to operate properly.

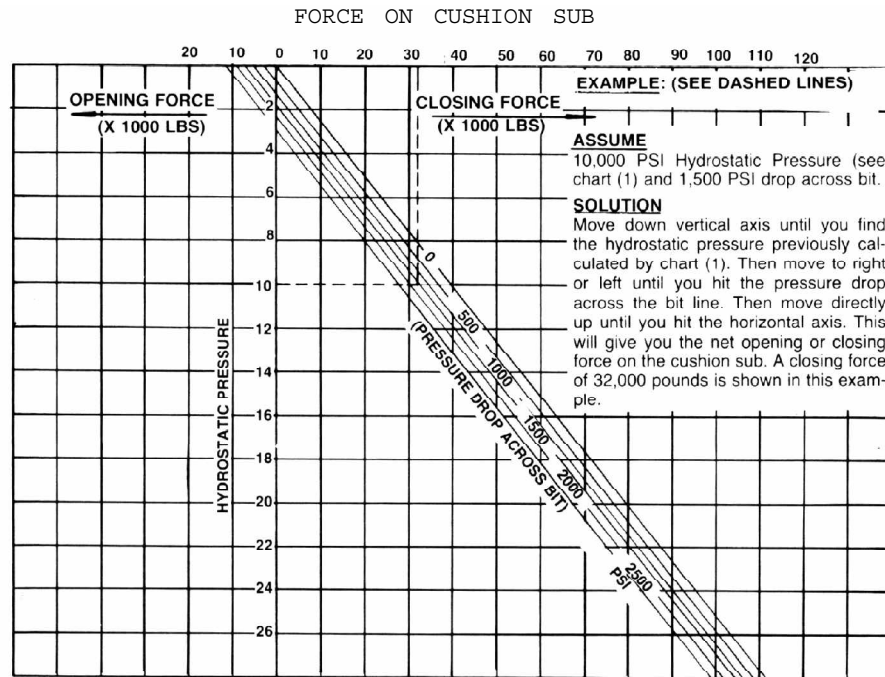
The following information is needed to use the graphs properly:

- 1) hole depth in feet
- 2) mud weight in pounds per gallon
- 3) pressure drop ACROSS the bit — NOT mud pump pressure in psi

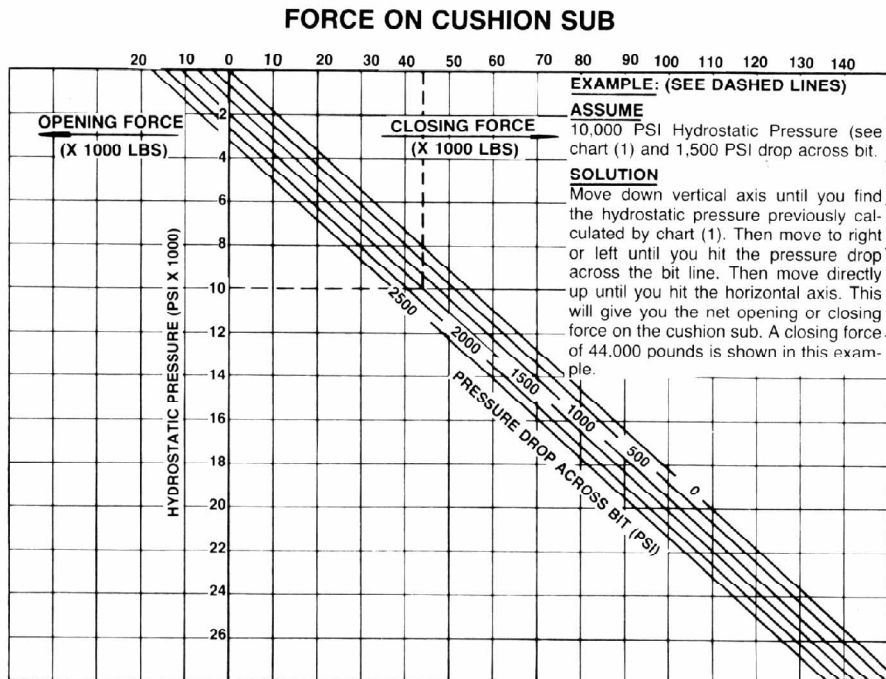
If pressure drop across the bit is unknown, then assume 50% of pump pressure for a tri-cone nozzle bit at average drilling depths.

Conversion Chart
Hole depth and mud weight to psi hydrostatic

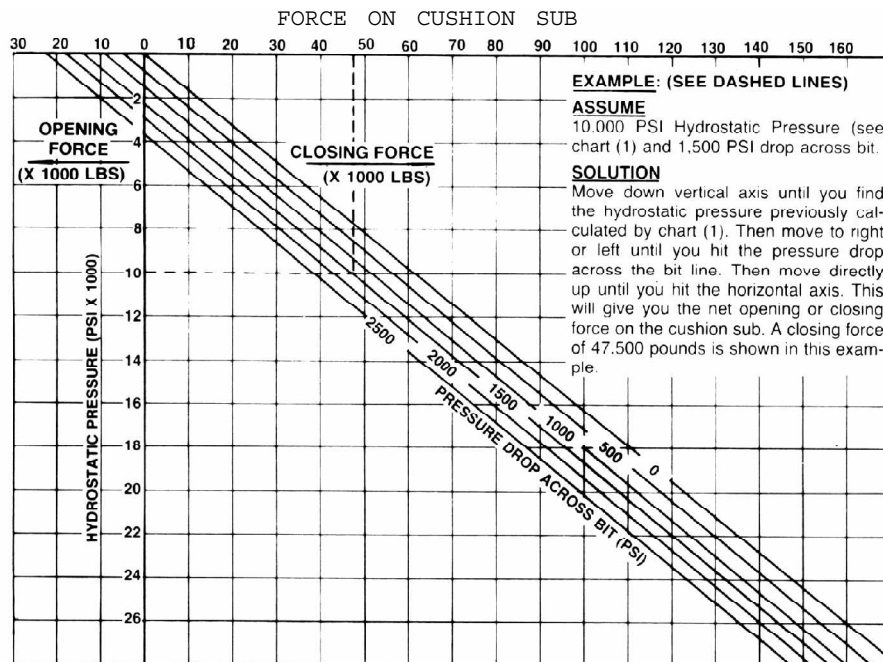




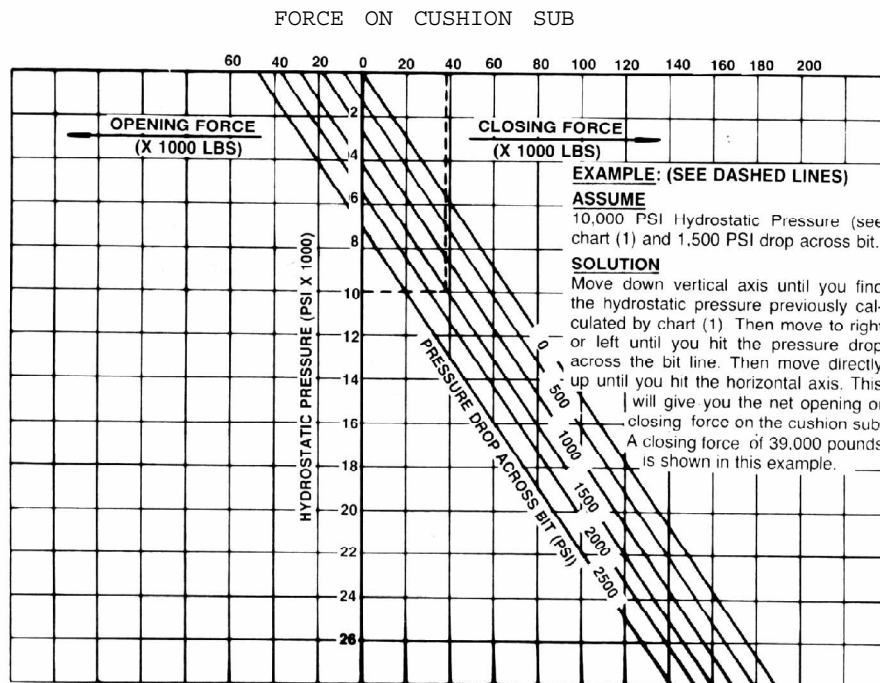
Bowen 4-3/4 to 5-1/2 Cushion Sub
Conversion Chart of Hydrostatic Pressure and Pressure Drop Across Bit to Net Pump Force



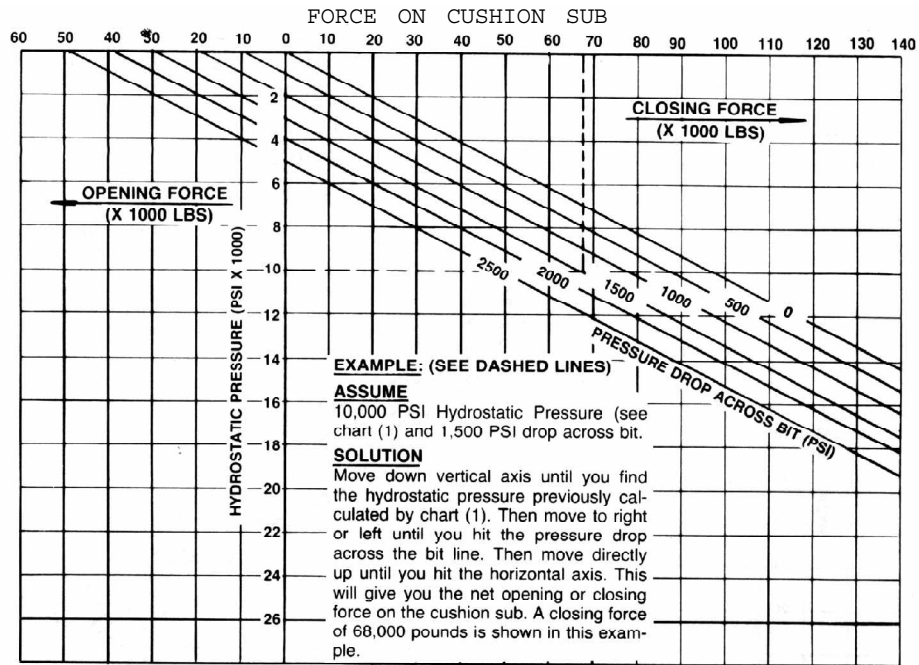
Bowen 6 to 6-1/4 Cushion Sub
Conversion Chart of Hydrostatic Pressure and Pressure Drop Across Bit to Net Pump Force



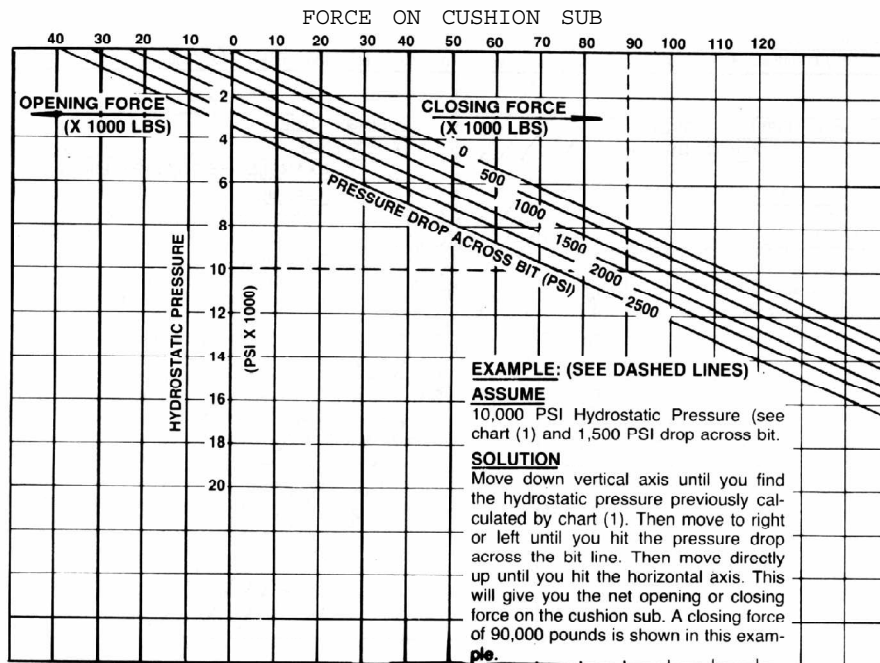
Bowen 6-1/2 to 7 Cushion Sub
Conversion Chart of Hydrostatic Pressure and Pressure Drop Across Bit to Net Pump Force



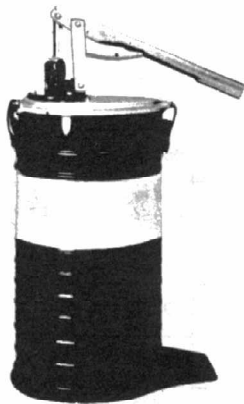
Bowen 8 to 8-1/2 Cushion Sub
Conversion Chart of Hydrostatic Pressure and Pressure Drop Across Bit to Net Pump Force



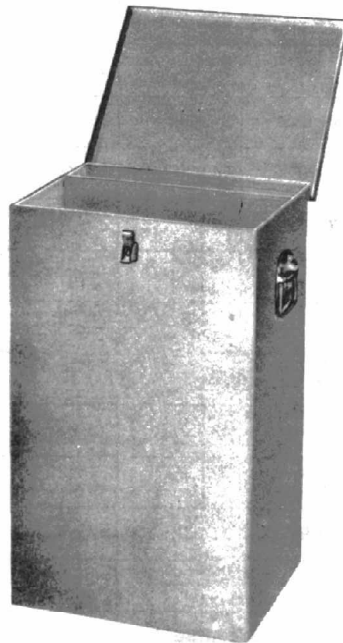
Bowen 9 to 9-1/2 Cushion Sub
Conversion Chart of Hydrostatic Pressure and Pressure Drop Across Bit to Net Pump Force



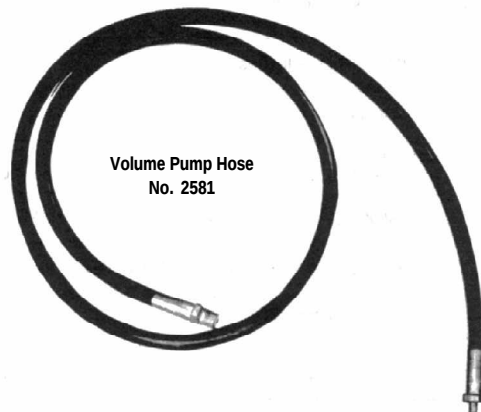
Bowen 11 to 12 Cushion Sub
Conversion Chart of Hydrostatic Pressure and Pressure Drop Across Bit to Net Pump Force



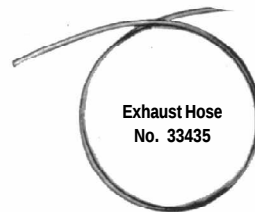
**Volume Pump
No. 2580**



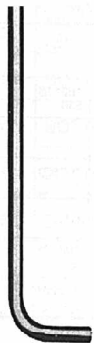
**Metal Box No. 1995
(Extra)**



**Volume Pump Hose
No. 2581**



**Exhaust Hose
No. 33435**



**Fill Plug Wrench
No. 38673**



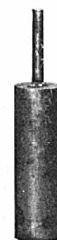
**Middle Body Packing
and Spline Body Packing
Installation Tool
(Optional)**



**Middle Body Packing
Disassembly Tool
(Optional)**



**Spline Body Packing and
Optional Pin Type Bottom Sub
Disassembly Tool
(Optional)**



**Bottom Sub Packing and
Mandrel Body Packing
Disassembly Tool
(Optional)**



**Volume Pump Repair Kit
No. 53266
(Extra)**



**Adapter Plug
No. 81377**



**Male Coupler
No. 656**



**Female Coupler
No. 655**



**Bushing
No. 2582**



**Line Filter
No. 56565**



**Bushing
No. 56563**



**Nipple
No. 56423**



**Tube Fitting
No. 33436**

Bowen Cushion Sub

Cushion Sub	4-3 4" O.D.	6 O.D.	6-12 O.D.	8 O.D.	9 O.D.	11" O.D.
Assembly No.	81454	81183	80891	80927	81300	102165
O.D. Range	4-3 4" - 5-1 4"	6" -6-1/ 4"	6-1 2" -7"	8" - 8-1/ 2"	9" - 9-1 2"	11" - 12"
I.D.	1-1 2"	1-3 4"	2-1/ 4"	2-1/ 2"	2-3 4"	3-1/16"
Connection	3-1 2" Reg.	4-1 2" Reg.	4-1 2" Reg.	6-5 8" Reg.	6-5 8" Reg. or 7-5 8" Reg.	7-5 8" Reg. or 8-5 8" Reg.
Length	14 Ft. 7-3/4 In.	14 Ft.	14 Ft.	15 Ft. 4-1/4 In.	15 Ft. 2-1/8 In.	18 Ft. 3-7/8 In.
Maximum Load	60,000 Lb.	76,000 Lb.	78,000 Lb.	110,000 Lb.	120,000 Lb.	120,000 Lb.
Stroke	6.0 In. Max.	8.0 In. Max.	8.0 In. Max.	8.0 In. Max.	6.0 In. Max.	8.0 In. Max.
Torque to Yield * (lb ft)	7,800	19,200	19,200	32,000	60,000	114,000
Lift Load at Yield * (lbs)	475,000	495,000	720,000	1,500,000	1,500,000	2,100,000
Working Fluid	Bowen Jar Lube 49842	Bowen Jar Lube 49842	Bowen Jar Lube 49842	Bowen Jar Lube 49842	Bowen Jar Lube 49842	Bowen Jar Lube 49842
Fluid Volume	165 In. ³	225 In. ³	275 In. ³	360 In. ³	515 In. ³	707 In. ³
Spring Rate (lb/in)	21,000	28,000	28,000	28,000	38,000	38,000

* Strengths listed are calculated theoretical yield points and are accurate within 20%.

Replacement Parts

Item No.								
1	Spline Body	Part No.	102008	81184	80892	80928	81302	102178
		Weight	68	99	169	245	302	530
2	Spline Body (Small) & Mandrel Body Packing Retainer	Part No.	—	81185	80903	80938	—	—
		Weight	—	1-1 /2	1-5/8	1-7/8	—	—
2	Spline Body (Long) & Mandrel Body Packing Retainer	Part No.	—	—	—	—	81311	102170
		Weight	—	—	—	—	7-1/2	6
2	Mandrel Body Packing Retainer	Part No.	102004	—	—	—	—	—
		Weight	1-1/16	—	—	—	—	—
3	Spline Body Packing Bearing	Part No.	102330	102306	102311	102316	102321	102325
		Weight	2	3	3	4	5	9
4	Spline Body & Mandrel Body Pressure Ring Set	Part No.	—	102390	102392	102394	102396	102207
		Weight	—	1/4	1	1/2	2	1/2
4	Spline Body Pressure Ring Set	Part No.	102422	—	—	—	—	—
		Weight	9/16	—	—	—	—	—
4a	Spline Body Female Adapter	Part No.	102423	—	—	—	—	—
		Weight	1/8	—	—	—	—	—
5	Spline Body & Mandrel Body Packing Support	Part No.	—	81188	80896	80932	81305	102173
		Weight	—	4-1/2	5-1/2	6-1/2	6-5/8	7
5	Spline Body Packing Support	Part No.	102009	—	—	—	—	—
		Weight	3-7/8	—	—	—	—	—
6	Spline Body & Mandrel Body Packing Support Bearing	Part No.	102329	102305	102310	102315	102320	102324
		Weight	1-1/2	1-3/4	2	2-1/2	4	9
7	Spline Body & Mandrel Body Packing Support Pressure Ring Set	Part No.	102388	81190	80898	80934	81307	102174
		Weight	3/16	3/8	1/2	3/8	1-1/4	1-1/2
7a	Spline Body & Mandrel Body Packing Support Female Adapter	Part No.	102389	—	—	—	—	—
		Weight	1/8	—	—	—	—	—
8	Spline Body Packing Retainer (Large)	Part No.	—	81191	80899	80935	—	—
		Weight	—	3-1/4	3-1/2	4-3/8	—	—
8	Spline Body Packing Retainer (Long)	Part No.	102012	—	—	—	—	—
		Weight	1-3/8	—	—	—	—	—
8	Spline Body Packing Retainer (Short)	Part No.	102007	—	—	—	81308	102176
		Weight	11/16	—	—	—	3-1/8	3-1/4
9	Fill Plug	Part No.	102025	80900	80900	80900	80900	80900
		Weight	1/16	1/8	1/8	1/8	1/8	1/8
10	Mandrel Body	Part No.	102002	81192	80901	80936	81309	102168
		Weight	11	25	35	44	73	110

Bowen Cushion Sub

11	Mandrel Body Wiper	Part No.	102603	102604	102605	102606	102607	102169
		Weight	3/16	3/16	1/4	3/8	1/2	1/2
12	Mandrel Body Bearing	Part No.	—	102304	102309	102314	102319	102172
		Weight	—	6	6	11	12	19
13	Mandrel	Part No.	102001	81195	80906	80940	102455	102167
		Weight	265	461	481	897	1,192	1,140
14	Mandrel Retainer	Part No.	102013	81196	80907	80941	81314	102180
		Weight	2-7/8	3-7/8	5-1/4	9	12-1/8	13
15	Middle Body	Part No.	102014	81197	80908	80942	81315	102179
		Weight	167	281	325	445	556	1,236
16	Middle Body Packing Retainer (Long)	Part No.	102015	81198	80909	—	81316	102182
		Weight	1-7/8	3	3-3/4	—	9-3/4	12
17	Middle Body Packing Bearing	Part No.	102331	102307	102312	—	102322	102326
		Weight	11/16	7	8	—	8	16
18	Middle Body Packing Set	Part No.	102017	81200	80911	—	81318	102183
		Weight	1-1/16	1-3/4	2-3/4	—	4-7/16	1-1/2
19	Middle Body Packing Support	Part No.	102018	81201	80912	80946	81319	102185
		Weight	5	9-1/2	12	9-1/2	17	14
20	Bottom Sub Packing Support Bearing	Part No.	102333	—	—	—	—	—
		Weight	1	—	—	—	—	—
20	Middle Body & Bottom Sub Packing Support Bearing & Bottom Sub Packing Bearings	Part No.	—	102308	102313	—	102323	—
		Weight	—	2	2	—	4	—
20	Middle Body Packing Support & Bottom Sub Packing Bearing	Part No.	102332	—	—	—	—	—
		Weight	1-1/2	—	—	—	—	—
21	Middle Body & Bottom Sub Packing Support Packing Set & Bottom Sub Packing Set	Part No.	—	81203	80914	—	81321	—
		Weight	—	9/16	3/4	—	1-1/2	—
21	Middle Body Packing Support & Bottom Sub Packing Set	Part No.	102020	—	—	—	—	—
		Weight	7/16	—	—	—	—	—
21	Bottom Sub Packing Support Packing Set	Part No.	102029	—	—	—	—	—
		Weight	5/16	—	—	—	—	—
22	Middle Body Packing Retainer (Short)	Part No.	102021	81204	80915	80949	81322	102188
		Weight	11/16	1-1/4	1-3/4	2-1/8	3-1/4	3
23	Bottom Sub	Part No.	102022	81205	80916	80950	81323	102192
		Weight	82	123	140	174	263	982
24	Bottom Sub Packing Retainer	Part No.	102023	81206	80917	80951	81324	102196
		Weight	1-1/8	3/4	1	1-1/4	5	3-3/4
25	Bottom Sub Packing Support	Part No.	102024	81207	80918	80952	81325	102193
		Weight	2-7/8	5-1/4	5-3/4	9-1/2	9-1/4	39
26	O-Ring	Part No.	568234	568342	568344	568357	568361	568363
27	O-Ring	Part No.	568238	568347	568351	568361	568364	568370
28	O-Ring	Part No.	568241	568348	568351	568361	568364	568370
29	O-Ring (Not a Seal)	Part No.	568142	568230	568236	568245	568249	568258
30	O-Ring	Part No.	568238	568245	568249	568259	568264	568269
31	O-Ring	Part No.	568240	568248	568252	568260	568263	568269
32	O-Ring	Part No.	568155	568249	568253	568260	568265	568270
33	O-Ring	Part No.	568243	568252	568255	568262	568266	568272
34	O-Ring	Part No.	568010	568108	568108	568108	568108	568108
35	Back-up Ring	Part No.	8-010	8-108	8-108	8-108	8-108	8-108
36	O-Ring	Part No.	—	—	—	568257	—	568267
37	O-Ring	Part No. ..	—	—	—	—	—	568445

Bowen Cushion Sub

38	O-Ring	Part No.	—	—	—	—	—	568368
39	O-Ring	Part No.	—	—	—	—	—	568251
40	O-Ring	Part No.	—	—	—	—	—	568249
41	Top Sub	Part No.	—	—	—	—	—	102166
42	O-Ring	Part No.	—	—	—	—	—	568444
43	O-Ring	Part No.	—	—	—	—	568431	568440
44	Spline Body & Mandrel Body Female Adapter	Part No.	—	102391	102393	102395	102397	102208
		Weight	—	1	1	1	—	2
45	Middle Body Packing Support (Long)	Part No.	—	—	—	102656	—	102191
		Weight	—	—	—	15-1/2	—	82
46	Mandrel Small End Bearing	Part No.	—	—	—	102318	—	—
		Weight	—	—	—	3-3/4	—	—
47	Mandrel Small End Packing Set	Part No.	—	—	—	80948	—	—
		Weight	—	—	—	3/4	—	—
48	Middle Body Packing Support (Short) & (Long) Packing Set	Part No.	—	—	—	—	—	102186
		Weight	—	—	—	—	—	1-1/2
49	Middle Body Packing Support (Short) & (Long) Bearing	Part No.	—	—	—	—	—	102327
		Weight	—	—	—	—	—	9
50	Middle Body Pkg. Support (Long) Wiper (Upper)	Part No.	—	—	—	—	—	102608
		Weight	—	—	—	—	—	1/2
51	Middle Body Packing Support (Long) Wiper (Lower)	Part No.	—	—	—	—	—	102609
		Weight	—	—	—	—	—	1/4
52	Bottom Sub & Bottom Sub Packing Support Packing Set	Part No.	—	—	—	—	—	102194
		Weight	—	—	—	—	—	1/2
53	Bottom Sub Packing Support & Bottom Sub Bearing	Part No.	—	—	—	—	—	102328
		Weight	—	—	—	—	—	5
54	Bottom Sub Packing Retainer (Long)	Part No.	—	—	—	—	—	102197
		Weight	—	—	—	—	—	4-3/4
55	Mandrel Extension	Part No.	—	—	—	—	—	102181
		Weight	—	—	—	—	—	305

Extra

56	Middle Body Packing Installation Tool	Part No.	102034	81285	81278	81281	81331	102202
57	Bottom Sub Packing Disassembly Tool	Part No.	102050	102067	102060	102063	102065	102206
58	Middle Body Packing Disassembly Tool	Part No.	102036	81345	81347	81350	81334	102205
59a	Spline Body Packing Disassembly Tool	Part No.	81358	81357	81356	81359	81360	102204
59b	Spline Body Packing Installation Tool	Part No.	102044	—	—	—	—	—
60	Mandrel Body Packing Disassembly Tool	Part No.	102035	81344	81347	81349	81334	102203

Optional

		3-1/2 Reg.	4-1/2 Reg.	4-1/2 Reg.	6-5/8 Reg.	6-5/8 7-5/8 Reg. Reg.	7-5/8 8-5/8 Reg. Reg.
61	O-Ring Packing Set	Part No. 102026	81208	80919	80953	81326	102198
62	Complete Packing Set	Part No. 102027	81209	80920	80954	81327	102199
63	Complete Bearing Set	Part No. 102339	102340	102341	102342	102343	102344
64	Lifting Sub Bottleneck Elevator Type for Box Connection	Part No. 102032	81430	81430	81431	81431/81432	81432/102237
65	Thread Protector for Pin Connection	Part No. 63078	63081	63081	63087	63087/65702	65702/102244
66	Thread Protector for Box Connection	Part No. 63095	63100	63100	63106	63106/81433	81433/102245
67	Lifting Sub for Pin Connection	Part No. 32276	32306	32306	32346	32346/81945	81945/102238
68	Lifting Sub for Box Connection	Part No. 59589	59591	59591	59593	59593/71374	—
69	Hi-temp O-ring Packing Set	Part No. 102372	102373	102374	102375	102376	102377
70	Hi-temp Complete Packing Set	Part No. 102584	102585	102586	102587	102588	102589
71	Cushion Sub Service Kit	Part No. 81368	81368	81368	81368	81368	81368
72	Bottom Sub Packing Disassembly Tool for Pin Connection	Part No. 102050	—	—	—	—	—
73	Mandrel Body Wiper (Hi-temp)	Part No. 102610	102611	102612	102613	102614	102615
74	Thread Lubricant (KOPR-KOTE)	Part No. 153823	—	—	—	—	—
75	Jar Lube	Part No. 49842	—	—	—	—	—

How To Order:

Specify:

- (1) Name and Number of Assembly or Part.
- (2) Size and Type of Connections, if Other than Standard.
- (3) Outside Diameter
- (4) Any Spares or Extras desired, by Name and Number.

Miscellaneous O-Ring Seals are normally furnished in sealed plastic bags of 10, 25, or 100 pieces each to prevent deterioration. Other quantities will be furnished in unsealed packages. Packing Sets, however, will always be furnished in sealed plastic bags.

Recommended Spare Parts:

- (1) 10 Complete Packing Sets
- (2) 5 Complete Bearing Sets
- (3) Spline Body and Mandrel Body Packing Support
- (4) 4 Fill Plugs
- (5) 1 Bottom Sub Packing Retainer
- (6) 6 "O" -Ring for Fill Plug

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Kilgore, Texas 75662
United States
Phone: 903 984 2553
Fax: 903 984 7170

10720 West I-20 East
Odessa, Texas 79765
United States
Phone: 432 563 1173
Fax: 432 563 1182

30444 Southwest Freeway
Rosenberg, Texas 77471
United States
Phone: 281 341 5365
Fax: 281 344 1986

Utah

1553 East Highway 40
Vernal, Utah 84078
United States
Phone: 435 789 0670
Fax: 435 789 6568

West Virginia

Route 2, Murphy Run Road
Clarksburg, West Virginia 26301
United States
Phone: 304 622 4303
Fax: 304 623 2174

Wyoming

1283 N. Derrick Drive
Unit 1, Box 2
Casper, Wyoming 82604
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Phone: 307 237 3100
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Edmonton, Alberta T6E 5P4
Canada
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Fax: 780 463 2348

3550 93 Street*
Edmonton, Alberta T6E 5N3
Canada
Phone: 780 944 3929
Fax: 780 430 0760

1100 540 5th Avenue SW (Mailing)
1010 540 5th Avenue SW (Office)
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* Denotes Manufacturing and Engineering facilities

Downhole Solutions

Drilling Solutions

Engineering and Project Management Solutions

Lifting and Handling Solutions

Production Solutions

Supply Chain Solutions

Tubular and Corrosion Control Solutions

Well Service and Completion Solutions